IN THE SPECIFICATION:

Please amend paragraph **[0003]** as follows:

[0003] Examples of solders that are known in the art to be useful in connecting semiconductor devices face down to higher level substrates include, but are not limited to, lead-tin (Pb/Sn) solder, silver-nickel (Ag/Ni) solder, copper, gold, and ~~conductive~~ conductive- or conductor-filled polymers. For example, 95/5 type Pb/Sn solder bumps (i.e., solder having about 95% by weight lead and about 5% by weight tin) have been used in flip-chip and ball grid array type attachments, including chip-scale packages (CSPs).

Please amend paragraph **[0010]** as follows:

[0010] The use of solder balls in connecting a semiconductor device face down to higher level substrates is also somewhat undesirable from the standpoint that, due to their generally spherical shapes, solder balls consume a great deal of area, or "real ~~estate",~~ estate," on a semiconductor device. Thus, solder balls can unduly limit the minimum spacing between the adjacent contact pads of a semiconductor device and, thus, the minimum pitch of the contact pads on the semiconductor device.

Please amend paragraph **[0011]** as follows:

[0011] Other types of conductive structures have been used to connect semiconductor devices, including those with relatively tight contact pad pitches, to substrates. Examples of these alternative conductive structures include pillars of conductive elastomer or ~~conductor filled~~ conductor-filled epoxy. When such conductive pillars are secured to the contact pads of a semiconductor device, however, the conductive materials from which these conductive structures are fabricated can bleed. This may cause the material to flow onto regions of the semiconductor device surrounding the contact pad, which may cause parasitic capacitance or even electrical shorts when adjacent conductive structures bleed into contact with each other or a conductive structure bleeds onto an adjacent contact pad.

Please amend paragraph **[0013]** as follows:

[0013] The inventors are not aware of any art that discloses reinforced~~, self-aligning~~ self-aligning conductive structures that facilitate the connection of a semiconductor device to a substrate while preventing conductive material from bleeding or flowing over the edges of contact pads to which the conductive structures are secured. Moreover, the inventors are not aware of methods that can be used to fabricate such reinforced conductive structures.

Please amend paragraph **[0014]** as follows:

[0014] In the past decade, a manufacturing technique termed ~~"stereolithography",~~ "stereolithography," also known as "layered ~~manufacturing",~~ manufacturing," has evolved to a degree where it is employed in many industries.

Please amend paragraph **[0015]** as follows:

[0015] Essentially, stereolithography, as conventionally practiced, involves utilizing a computer to generate a three-dimensional (3-D) mathematical simulation or model of an object to be fabricated, such generation usually effected with 3-D ~~computer-aided~~ computer-aided design (CAD) software. The model or simulation is mathematically separated or "sliced" into a large number of relatively thin, parallel, usually vertically superimposed layers, each layer having defined boundaries and other features associated with the model (and thus the actual object to be fabricated) at the level of that layer within the exterior boundaries of the object. A complete assembly or stack of all of the layers defines the entire object, and surface resolution of the object is, in part, dependent upon the thickness of the layers.

Please amend paragraph **[0018]** as follows:

[0018] In more recent years, stereolithography has been employed to develop and refine object designs in relatively inexpensive materials, and has also been used to fabricate small quantities of objects where the cost of conventional fabrication techniques is prohibitive for same,

such as in the case of plastic objects conventionally formed by injection molding. It is also known to employ stereolithography in the custom fabrication of products generally built in small quantities or where a product design is rendered only once. Finally, it has been appreciated in some industries that stereolithography provides a capability to fabricate products, such as those including closed interior chambers or convoluted passageways, which cannot be fabricated satisfactorily using conventional manufacturing techniques. It has also been recognized in some industries that a stereolithographic object or component may be formed or built around another, ~~pre-existing~~ pre-existing object or component to create a larger product.

Please amend paragraph **[0029]** as follows:

[0029] Following the fabrication of a hollow jacket, a quantity of unconsolidated (e.g., particulate, molten, or uncured liquid) ~~conductive or conductor-filled~~ conductive- or conductor-filled material is disposed in the centers of the jackets. Alternatively, stereolithography may also be used to form the conductive centers of the male and female members from an electrically conductive photopolymer. If stereolithography is used to fabricate the conductive centers, the conductive center of at least one of a corresponding pair of members is preferably left at least partially unconsolidated so as to facilitate the subsequent formation of an integral conductive center through the conductive structure.

Please amend paragraph **[0033]** as follows:

[0033] FIG. 3 is an enlarged partial perspective view of a female member on the carrier substrate of FIG. 1;

Please amend paragraph **[0035]** as follows:

[0035] FIG. 5 is a bottom plan view of the carrier substrate of FIG. 1;

Please amend paragraph **[0036]** as follows:

[0036] FIG. 6 is a cross-sectional view depicting the semiconductor device and the carrier substrate of FIG. 1 in an assembled relationship with the male members and the female members interconnected;

Please amend paragraph **[0041]** as follows:

[0041] FIG. 11 is a schematic representation of an exemplary stereolithography apparatus that can be employed in the method of the present invention to fabricate ~~the~~ a jacket of a male member of a conductive structure of the present invention; and

Please amend paragraph **[0043]** as follows:

[0043] With reference to FIGs. 1 and 4-6, a semiconductor device ~~assembly 10,~~ assembly, including a semiconductor device 10 and a substrate 20, is shown. Semiconductor device 10 is a flip-chip type device, such as a flip-chip die or a ball grid array package, or a ~~flip-chip~~ flip-chip type chip-scale package having contact pads 12 (FIG. 6) on a surface 14 thereof that can each be bonded to corresponding contact pads 22 (FIG. 6) of a surface 24 of substrate 20 by way of conductive structures 30.

Please amend paragraph **[0048]** as follows:

[0048] As illustrated, the periphery of the end portion 43′ of jacket 42′ is smaller than the periphery of the remainder of jacket 42′, with an outer ledge 48 being formed at the junction between end portion 43′ and the remainder, or base portion 45′, of jacket 42′. When male member 40′ is interconnected with female member 50′, a complementarily configured upper portion 58′ of aperture 54′ receives end portion 43′ of male member 40′ and outer ledge 48 prevents further insertion of male member 40′ into aperture 54′ of female member 50′. Thus, outer ledge 48 defines a minimum length of conductive structure 30′ and a minimum distance between an assembled semiconductor device 10 and substrate 20.

Please amend paragraph **[0052]** as follows:

[0052] Turning now to FIG. 10, a wafer 72 with a plurality of semiconductor devices 10 thereon is illustrated. Each semiconductor device 10, which has yet to be singulated, or diced, from wafer 72, has female members 50 of conductive structures 30 secured to the contact pads 12 (see ~~FIG. 8)~~ FIG. 7) thereof. Each semiconductor device 10 on wafer 72 is separated from adjacent semiconductor devices 10 by a street 74.

Please amend paragraph **[0055]** as follows:

[0055] The jackets are preferably fabricated from a photo-curable polymer, or ~~"photopolymer",~~ "photopolymer," by stereolithographic processes. When fabricated directly on a semiconductor device 10 or substrate 20, the jackets can be made either before or after preformed conductive centers 46, 56 are connected to contact pads 12 of semiconductor device 10 or to contact pads 22 of substrate 20.

Please amend paragraph **[0060]** as follows:

[0060] Apparatus 80 also includes a reservoir 84 (which may comprise a removable reservoir interchangeable with others containing different materials) of an unconsolidated material 86 to be employed in fabricating the intended object. In the currently preferred embodiment, the unconsolidated material 86 is a liquid, photo-curable polymer, or ~~"photopolymer",~~ "photopolymer," that cures in response to light in the UV wavelength range. The surface level 88 of material 86 is automatically maintained at an extremely precise, constant magnitude by devices known in the art responsive to output of sensors within apparatus 80 and preferably under control of computer 82. A support platform or elevator 90, precisely vertically movable in fine, repeatable increments in direction 116 responsive to control of computer 82, is located for movement downward into and upward out of material 86 in reservoir 84.

Please amend paragraph **[0061]** as follows:

[0061] An object may be fabricated directly on platform 90 or on a substrate disposed on platform 90. When the object is to be fabricated on a substrate disposed on platform 90, the

substrate may be positioned on platform 90 and secured thereto by way of one or more base supports 122 (see FIG. 12). Such base supports 122 may be fabricated before or simultaneously with the stereolithographic fabrication of one or more objects on platform 90 or a substrate disposed thereon. These base supports 122 may support, or prevent lateral movement of, the substrate or object being formed relative to a surface 100 of platform 90. ~~Supports~~ Base supports 122 may also provide a perfectly horizontal reference plane for fabrication of one or more objects thereon, as well as facilitate the removal of a substrate or formed object from platform 90 following the stereolithographic fabrication of one or more objects on the substrate. Moreover, where a so-called "recoater" blade 102 is employed to form a layer of material on platform 90 or a substrate disposed thereon, base supports 122 can preclude inadvertent contact of recoater blade 102, to be described in greater detail below, with surface 100 of platform 90.

Please amend paragraph **[0064]** as follows:

[0064] When one or more base supports 122 are to be stereolithographically fabricated, base supports 122 may be programmed as a separate STL file from the other objects to be fabricated. The primary STL file for the object or objects to be fabricated and the STL file for base support(s) 122 are merged.

Please amend paragraph **[0065]** as follows:

[0065] Before fabrication of a first layer for a base support 122 or an object is commenced, the operational parameters for apparatus 80 are set to adjust the size (diameter if circular) of the laser light beam used to cure material 86. In addition, computer 82 automatically checks and, if necessary, adjusts by means known in the art, the surface level 88 of material 86 in reservoir 84 to maintain same at an appropriate focal length for laser beam 98. U.S. Patent No. 5,174,931, referenced above and previously incorporated herein by reference, discloses one suitable level control system. Alternatively, the height of mirror 94 may be adjusted responsive to a detected surface level 88 to cause the focal point of laser beam 98 to be located precisely at the surface of material 86 at surface level 88 if surface level 88 is permitted to vary, although this approach is more complex. Platform 90 may then be submerged in material 86 in reservoir 84 to

a depth equal to the thickness of one layer or slice of the object to be formed, and the liquid surface level 88 is readjusted as required to accommodate material 86 displaced by submergence of platform 90. Laser 92 is then activated so laser beam 98 will scan unconsolidated (e.g., liquid or powdered) material 86 disposed over surface 100 of platform 90 to at least partially consolidate (e.g., polymerize to at least a semisolid state) material 86 at selected locations, defining the boundaries of a first layer 122A of base support 122 and filling in solid portions thereof. Platform 90 is then lowered by a distance equal to thickness of second layer 122B, and laser beam 98 is scanned over selected regions of the surface of material 86 to define and fill in the second layer 122B, while simultaneously bonding the second layer 122B to the first layer 122A. The process may then be repeated as often as necessary, layer by layer, until base support 122 is completed. Platform 90 is then moved relative to mirror 94 to form any additional base supports 122 on platform 90 or a substrate disposed thereon or to fabricate objects upon platform 90, base support 122, or a substrate, as provided in the control software. The number of layers required to erect base support 122 or one or more other objects to be formed depends upon the height of the object or objects to be formed and the desired layer thickness 108, 110. The layers of a stereolithographically fabricated structure with a plurality of layers may have different thicknesses.

Please amend paragraph **[0066]** as follows:

[0066] If a recoater blade 102 is employed, the process sequence is somewhat different. In this instance, surface 100 of platform 90 is lowered into unconsolidated (e.g., liquid) material 86 below surface level 88 a distance greater than a thickness of a single layer of material 86 to be cured, then raised above surface level 88 until platform 90, a substrate disposed thereon, or a structure being formed on either platform 90 or a substrate thereon, is precisely one layer's thickness below blade 102. Blade 102 then sweeps horizontally over platform 90 or (to save time) at least over a portion thereof on which one or more objects are to be fabricated to remove excess material 86 and leave a film of precisely the desired thickness. Platform 90 is then lowered so that the surface of the film ~~and material~~ and, thus, surface level 88 are coplanar and the surface of the unconsolidated material 86 is still. Laser 92 is then initiated to scan with

laser beam 98 and define the first layer 130. The process is repeated, layer by layer, to define each succeeding layer 130 and simultaneously bond same to the next lower layer 130 until all of the layers of the object or objects to be fabricated are completed. A more detailed discussion of this sequence and apparatus for performing same is disclosed in U.S. Patent 5,174,931, previously incorporated herein by reference.

Please amend paragraph **[0067]** as follows:

[0067] As an alternative to the above approach to preparing a layer of material 86 for scanning with laser beam 98, a layer of unconsolidated (e.g., liquid) material 86 may be formed on surface 100 of support platform 90, on a substrate disposed on platform 90, or on one or more objects being fabricated by lowering platform 90 to flood material 86 over surface 100,~~ over a~~ <u>over the </u>substrate disposed thereon, or over the highest completed layer of the object or objects being formed, then raising platform 90 and horizontally traversing a so-called "meniscus" blade horizontally over platform 90 to form a layer of unconsolidated material having the desired thickness over platform 90, the substrate, or each of the objects being formed. Laser 92 is then initiated and a laser beam 98 scanned over the layer of unconsolidated~~ material~~ <u>material 86 </u>to define at least the boundaries of the solid regions of the next higher layer of the object or objects being fabricated.

Please amend paragraph **[0070]** as follows:

[0070] In practicing the present invention, a commercially available stereolithography apparatus operating generally in the manner as that described above with respect to apparatus 80 of FIG. 11 is preferably employed, but with further additions and modifications as hereinafter described for practicing the method of the present invention. For example and not by way of limitation, the SLA-250/50HR, SLA-5000 and SLA-7000 stereolithography systems, each offered by 3D Systems, Inc., of Valencia, California, are suitable for modification. Photopolymers believed to be suitable for use in practicing the present invention include Cibatool SL 5170 and SL 5210 resins for the SLA-250/50HR system, Cibatool SL 5530 resin for

the SLA-5000 and 7000 systems, and Cibatool SL 7510 resin for the SLA-7000 system. All of these photopolymers are available from Ciba Specialty Chemicals ~~Corporation.~~ Inc.

Please amend paragraph **[0071]** as follows:

[0071] By way of example and not limitation, the layer thickness of material 86 to be formed, for purposes of the invention, may be on the order of about 0.0001 to 0.0300 inch, with a high degree of uniformity. It should be noted that different material layers may have different heights so as to form a structure of a precise, intended total height or to provide different material thicknesses for different portions of the structure. The size of the laser beam "spot" impinging on the surface of material 86 to consolidate (e.g., cure) same may be on the order of 0.001 inch to 0.008 inch. Resolution is preferably ∀0.0003 inch in the X-Y plane (parallel to surface 100) over at least a 0.5 inch H 0.25 inch field from a center point, permitting a high resolution scan effectively across a 1.0 inch H 0.5 inch area. Of course, it is desirable to have substantially this high a resolution across the entirety of surface 100 of platform 90 to be scanned by laser beam 98, such area being termed the "field of ~~exposure",~~ exposure," and being substantially coextensive with the vision field of a machine vision system employed in the apparatus of the invention as explained in more detail below. The longer and more effectively vertical the path of laser beam 96/98, the greater the achievable resolution.

Please amend paragraph **[0072]** as follows:

[0072] Referring again to FIG. 11, it should be noted that apparatus 80 useful in the method of the present invention includes a camera 140 which is in communication with computer 82 and preferably located, as shown, in close proximity to optics and mirror 94 located above surface 100 of support platform 90. Camera 140 may be any one of a number of commercially available cameras, such as capacitive-coupled discharge (CCD) cameras available from a number of vendors. Suitable circuitry as required for adapting the output of camera 140 for use by computer 82 may be incorporated in a board 142 installed in computer 82, which is programmed, as known in the art, to respond to images generated by camera 140 and processed by board 142. Camera 140 and board 142 may together comprise a so-called "machine vision

system" and, specifically, a "pattern recognition system" (PRS), operation of which will be described briefly below for a better understanding of the present invention. Alternatively, a self-contained machine vision system available from a commercial vendor of such equipment may be employed. For example, and without limitation, such systems are available from Cognex Corporation of Natick, Massachusetts. For example, the apparatus of the Cognex BGA ~~Inspection Package™~~ INSPECTION PACKAGE™ or the SMD ~~Placement Guidance Package™~~ PLACEMENT GUIDANCE PACKAGE™ may be adapted to the present invention, although it is believed that the MVS-8000™ product family and the ~~Checkpoint®~~ CHECKPOINT® product line, the latter employed in combination with Cognex ~~PatMax™~~ PATMAX™ software, may be especially suitable for use in the present invention.

Please amend paragraph **[0074]** as follows:

[0074] In order to facilitate fabrication of one or more dielectric jackets 52 in accordance with the method of the present invention with apparatus 80, a data file representative of the size, configuration, thickness and surface topography of, for example, a particular type and design of semiconductor device 10 or other substrate upon which one or more jackets 52 are to be mounted, is placed in the memory of computer 82. Also, as jackets 52 are configured to be interconnected with complementary jackets 42 (see FIGs. 1 and 6) of male members 40 on another substrate, a data file representative of the substrate to which male members ~~42 are~~ 40 are to be secured and the features thereof, as well as a data file representative of male members 40, may be placed in memory.

Please amend paragraph **[0077]** as follows:

[0077] Continuing with reference to FIGs. 11 and 12, wafer 72 or the one or more semiconductor devices 10 or other substrates on platform 90 may then be submerged partially below the surface level 88 of liquid material 86 to a depth greater than the thickness of a first layer of material 86 to be at least partially consolidated (e.g., cured to at least a semisolid state) to form the lowest layer 130 of each dielectric jacket 52 at the appropriate location or locations on each semiconductor device 10 or other substrate, then raised to a depth equal to the layer

thickness, surface level 88 of material 86 being allowed to become calm. Photopolymers that are useful as material 86 exhibit a desirable dielectric constant, low shrinkage upon cure, are of sufficient (i.e., semiconductor grade) purity, exhibit good adherence to other semiconductor device materials, and have a similar coefficient of thermal expansion (CTE) to the material of conductive centers 46, 56 (FIGs. 1-6) (e.g., solder or other metal or metal alloy, conductive resin, or conductive elastomer). Preferably, the CTE of material 86 is sufficiently similar to that of the material of conductive centers 46, 56 to prevent undue stressing thereof during thermal cycling of semiconductor device 10 or substrate 20 in testing, subsequent processing, and subsequent normal operation. Exemplary photopolymers exhibiting these properties are believed to include, but are not limited to, the above-referenced resins from Ciba Specialty ~~Chemical Company.~~ Chemicals Inc. One area of particular concern in determining resin suitability is the substantial absence of mobile ions and, specifically, fluorides.

Please amend paragraph **[0078]** as follows:

[0078] Laser 92 is then activated and scanned to direct beam 98, under control of computer 82, toward specific locations of surface level 88 relative to each semiconductor device 10 or other substrate to effect the aforementioned partial cure of material 86 to form a first layer 52A of each jacket 52. Platform 90 is then lowered into reservoir 84 and raised a distance equal to the desired thickness of another layer 52B of each jacket 52, and laser 92 is activated to add another layer 52B to each jacket 52 under construction. This sequence continues, layer by layer, until each of the layers of jackets 52 have been completed.

Please amend paragraph **[0080]** as follows:

[0080] Each layer 52A, 52B of a dielectric jacket 52 is preferably built by first defining any internal and external object boundaries of that layer with laser beam 98, then hatching solid areas of jacket 52 located within the object boundaries with laser beam 98. An internal boundary of a layer may comprise aperture 54, a through-hole, a void, or a recess in jacket 52, for example. If a particular layer includes a boundary of a void in the object above or below that layer, then laser beam 98 is scanned in a series of ~~closely spaced,~~ closely spaced, parallel vectors so as to

develop a continuous surface, or skin, with improved strength and resolution. The time it takes to form each layer depends upon the geometry thereof, the surface tension and viscosity of material 86, and the thickness of that layer.

Please amend paragraph **[0081]** as follows:

[0081] Alternatively, dielectric jackets 52 may each be formed as a partially cured outer skin extending above surface 14 of semiconductor device 10 or above surface 24 of substrate 20 and forming a dam within which unconsolidated material 86 can be contained. This may be particularly useful where the jackets 52 protrude a relatively high distance 60 from surface 14. In this instance, support platform 90 may be submerged so that material 86 enters the area within the dam, raised above surface level 88, and then laser beam 98 activated and scanned to at least partially cure material 86 residing within the dam or, alternatively, to merely cure a "skin" comprising the surface of dielectric jackets 52, a final cure of the ~~material~~ material 86 of the jackets 52 being effected subsequently by broad-source UV radiation in a chamber or by thermal cure in an oven. In this manner, jackets 52 of extremely precise dimensions may be formed of material 86 by apparatus 80 in minimal time.

Please amend paragraph **[0082]** as follows:

[0082] When dielectric jackets 52″, depicted in FIG. 8, are being fabricated on a substrate, such as semiconductor device 10, having a conductive center 56″ already secured to the contact pads 12 thereof, some of material 86 may be located in shadowed areas 53 (see FIG. 8). As laser beam 98 is directed substantially vertically downwardly toward surface level 88 of material 86, material 86 located in shadowed regions 53 will not be contacted or altered by laser beam 98. Nonetheless, the unconsolidated material 86 in shadowed areas 53 will become trapped therein as material 86 adjacent to and laterally outward from shadowed areas 53 is at least partially consolidated and as jacket 52 is built up around conductive center 56″. Such trapped, unconsolidated material 86 will eventually cure due to the cross-linking initiated in the outwardly adjacent photopolymer, and the cure can be subsequently accelerated as known in the art, such as by a thermal cure.

Please amend paragraph **[0090]** as follows:

[0090] The stereolithography fabrication process may also advantageously be conducted at the wafer level or on multiple substrates, saving fabrication time and expense. As the stereolithography method of the present invention recognizes specific semiconductor devices 10 or other substrates 20, variations between individual substrates are accommodated. Accordingly, when the stereolithography method of the present invention is employed, jackets 52 can be simultaneously fabricated on different types of semiconductor devices 10 or other ~~substrates,~~ substrates 20, as well as on both semiconductor devices 10 and other ~~substrates.~~ substrates 20.

Please amend paragraph **[0091]** as follows:

[0091] Of course, other known methods can also be used to fabricate the jackets of the conductive structures of the present invention. Exemplary methods include, but are not limited to, ~~the~~ use of photoresist materials to form ~~the~~ reinforcement structures and fabrication of the reinforcement structure from dielectric materials using known semiconductor device patterning (e.g., mask and etch) processes.